Once the phase contrast image of the object is displayed via the display **141**, the user may select a target constituent substance of the object that the user wishes to know quantitative data thereof based on the displayed image. If the user inputs selection for the constituent substance (operation **334**), a substance image containing thickness data regarding the selected constituent substance is formed (operation **335**), and the formed substance image is displayed. As described above, to allow the substance image to contain the thickness data, brightness of each pixel may correspond to the thickness data regarding the corresponding pixel.

FIG. **20** is a flowchart showing generation of a thickness map on a per constituent substance basis in the control method for the X-ray imaging apparatus according to an exemplary embodiment.

Referring to FIG. **20**, phase contrast image signals on a per energy band basis with regard to the object are acquired (operation **340**), and thickness data regarding constituent substances of the object is estimated using the acquired phase contrast image signals (operation **341**). Estimation of the thickness data may be implemented on a per constituent substance basis, on a per pixel (corresponding to the constituent substance) basis, or on a per predefined region basis. The present exemplary embodiment assumes that estimation of the thickness data is implemented on a per pixel basis.

It is judged whether the estimated thickness data satisfies a verification requirement (operation **342**). If the estimated thickness data does not satisfy the verification requirement (No of Operation **342**), a regularization function is applied to estimate new thickness data regarding the constituent substances.

If the estimated thickness data satisfies the verification requirement (Yes of Operation **342**), finally estimated thickness data is acquired as final thickness data, and the acquired thickness data is added to a thickness map of the corresponding constituent substance (operation **343**).

Then, it is judged whether estimation of the thickness data is completed with regard to all pixels corresponding to the constituent substance (operation **344**). If estimation of the thickness data is completed with regard to only some of the pixels (No of Operation **344**), estimation of the thickness data with regard to the remaining pixels is implemented and the resulting thickness data is added to the thickness data map.

If estimation of the thickness data is completed with regard to all the pixels (Yes of Operation **344**), it is judged whether estimation of the thickness data is completed with regard to all constituent substances (operation **345**). If estimation of the thickness data is completed with regard to only some of the constituent substances (No of Operation **345**), estimation of the thickness data with regard to the remaining constituent substances is implemented to generate a thickness data map. If estimation of the thickness data is completed with regard to all of the constituent substances (Yes of Operation **345**), generation of the thickness data map ends.

The control method for the X-ray imaging apparatus may utilize the aforementioned thickness map to display thickness data regarding each constituent substance or to form a substance image containing the thickness data.

FIGS. **18** and **19** illustrate formation of each substance image containing thickness data regarding each constituent substance. FIG. **21** is a flowchart showing generation of a single image containing thickness data on a per constituent substance basis in the control method for the X-ray imaging apparatus according to an exemplary embodiment.

Referring to FIG. **21**, phase contrast image signals on a per energy band basis with regard to the object are acquired (operation **350**), and thickness data on a per constituent substance basis is acquired using the acquired phase contrast image signals (operation **351**). Acquisition of the thickness data may be implemented via iterative calculation and estimation.

A thickness map on a per constituent substance basis is generated using the acquired thickness data (operation **352**), and a substance image containing thickness data on a per constituent substance basis is formed (operation **353**). Formation of the substance image is described above.

Different color channels are mapped to a substance image on a per constituent substance basis (operation **354**). For example, in the case of using an RGB color space, an R channel may be mapped to a constituent substance A, a G channel may be mapped to a constituent substance B, and a B channel may be mapped to a constituent substance C. Thickness data included in each substance image is represented by a mapped channel value. For example, in the image of the constituent substance A, a value of the R channel of each pixel may vary according to thickness data on a per pixel basis. This is equally applied to the other two images. There is no limit as to the color space used in the exemplary embodiments. For example, various other color spaces, such as a YCbCr color space, a CMY color space, a CMYK color space, etc., may be used.

The substance images, to which the color channels have been mapped, composed and displayed (operation **355**). In the composite image, the respective constituent substances are distinguished by different colors, and thickness data regarding the respective constituent substances is represented as brightness.

Although thickness data has been described as quantitative data regarding the constituent substances in the above exemplary embodiments with regard to the control method for the X-ray imaging apparatus, the above description except for the aforementioned equations may be applied to other quantitative data.

As is apparent from the above description, according to an exemplary embodiment, it may be possible to estimate quantitative data regarding an object using phase contrast image signals corresponding to a plurality of different energy bands, thereby providing a user with the estimated data in various ways.

Although a few exemplary embodiments have been shown and described, exemplary embodiments are not limited thereto. It would be appreciated by those skilled in the art that changes may be made in these exemplary embodiments without departing from the principles and spirit of the disclosure, the scope of which is defined in the claims and their equivalents.

What is claimed is:

1. An X-ray imaging apparatus comprising:

an X-ray source configured to generate X-rays and emit the X-rays to an object;

an X-ray detector configured to detect X-rays having passed through the object for each of a plurality of different energy bands, and acquire phase contrast image signals on a per energy band basis, for each of the plurality of different energy bands;

a quantitative data acquirer configured to calculate approximate quantitative data of two or more constituent substances of the object using a relation between the phase contrast image signals on the per energy band basis and quantitative data of the constituent substances, and estimate quantitative data of the constituent substances by iteratively applying a regularization function to the approximate quantitative data; and